

Research Article

Salmonella Contamination in Table Eggs and Meat from Broiler in Germany from 1992 to 2011

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Abstract

This research article investigates Salmonella contamination in table eggs and broiler meat in Germany between 1992 and 2011. Data spanning two decades were analyzed to understand the factors influencing Salmonella contamination in poultry products and its impact on human cases of salmonellosis. The study reveals a historical perspective on Salmonella surveillance in Germany, emphasizing significant changes in surveillance strategies over the years. Since 1992, the data on Salmonella contamination in food were systematically collected, providing insights into the trends and patterns of contamination. The study highlights the pivotal role of table eggs as a major source of human salmonellosis, leading to the formulation of new regulations in 1994. The establishment of the zoonoses order in 1993 marked a significant step towards enhanced surveillance and reporting at the European level. The European Union's guidelines on zoonoses and the establishment of reference laboratories further strengthened the surveillance systems, facilitating data sharing and analysis across European countries. The introduction of national reporting officers and community reference laboratories for zoonotic agents improved data accuracy and consistency. The study showcases a correlation analysis method implemented since 2010, enhancing the understanding of the relationship between Salmonella contamination in poultry products and human infections. Results indicate a gradual reduction in Salmonella contamination levels in table eggs and poultry meat over the years, reflecting the effectiveness of regulatory measures and surveillance protocols. Overall, this research underscores the importance of continuous monitoring and surveillance in mitigating Salmonella-related risks in the food chain. The findings provide valuable insights for policymakers, health authorities, and stakeholders in enhancing food safety measures and reducing the burden of salmonellosis on public health.

Keywords

Salmonella, 1992-2011, Yearly Collection of Zoonoses Data, Yearly Books on Zoonoses, European Data Collection

1. Introduction

This contribution will show, which factors are responsible for the development of the Salmonella contamination in food (poultry meat and table eggs), and will show, how these contaminations have an influence for the salmonellosis in humans. Since 1992 data of the salmonella contamination in food were saved for all years in a database [29]. There was a

possibility to compare the years back to 1992. The data in this contribution were from 1992 to 2011. In 1992 were about 200 000 salmonellosis reported from humans (Figure 1). The history of salmonella surveillance has been changed during the years (cf. Figure 3). The consequences of this development will be discussed.

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The Salmonella surveillance in Germany was performed since many years (from 1961 [31]). In the 1980 years the detailed salmonella surveillance was dropped, because of the costs and also, that there were no further problems with salmonellosis [31]. 1990 was with help by Dr. Pietzsch in the former Federal Health Institute a new start with the salmonella surveillance. In this time a new problem with salmonellosis from 1988 was observed. At the new start the details of the surveillance were simple. The yearly salmonella surveillance was a base for the causes for human salmonellosis. The main cause for the human salmonellosis could be found: table eggs. The results were used for the new table egg order (1994).

Since 1993 the zoonoses order was introduced (92/117/EEC). The Federal Health Institute was named for the European reference laboratory for the Epidemiology of Zoonoses. The concept of the Federal Health Institute was the introduction of a European Surveillance System with special reference laboratories for Zoonoses. In Germany the laboratories were responsible mainly in the Federal Health Institute. 1995 was founded a working group in the Federal Institute for Consumer Protection and Veterinary Medicine (BgVV, the following institute for the Federal Health Institute) for the founding of the Community Reference Laboratories for the Epidemiology of Zoonoses. Due to a formulation of the European Union the work of the European reference institute

has to be divided from the national reference Institute. The work of the Community Reference Laboratory for the Epidemiology of the Zoonoses was from this time on an own group. 1996 was named the German National Reference Laboratory of the Epidemiology of Zoonoses. The work of the Reference Laboratories was carried out in the later Federal Institute of Risk Assessment ([1, 3], BfR).

Since 2003 the new Zoonoses Guideline was in order (2003/99/EU). Since 2004 the zoonoses occurrence data were compiled in the EFSA (Parma) for whole Europe [4]. Since 2005 national Reporting Officers were introduced. In Germany the Reporting Officer was named and the National Reference Laboratory was dropped. At this time the Community Reference Laboratories were introduced for different zoonoses agents (EU No. 882/2004).

Later the data of the regions from the food protection in the Federal States of Germany institutions from Animals, Food, Feed and Environment were compiled yearly in a book.

The data of Germany were compiled with information from the Reference laboratories for the different zoonosis agents and sent to the EFSA (Parma, [4, 5]).

Till 2004 the zoonosis data sent by questionnaires, which were at first manually given into and from 2005 on automatically red into a database.

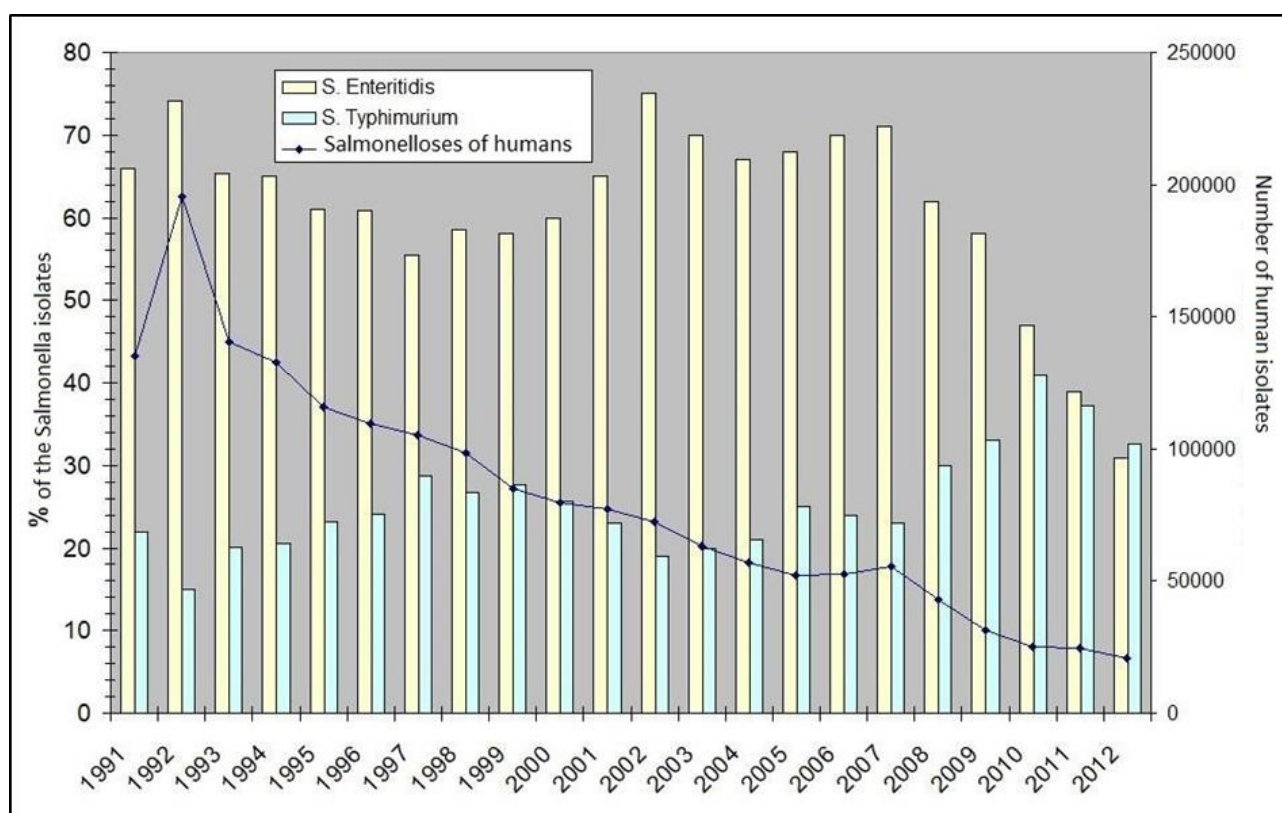


Figure 1. Salmonellosis in humans 1991-2012.

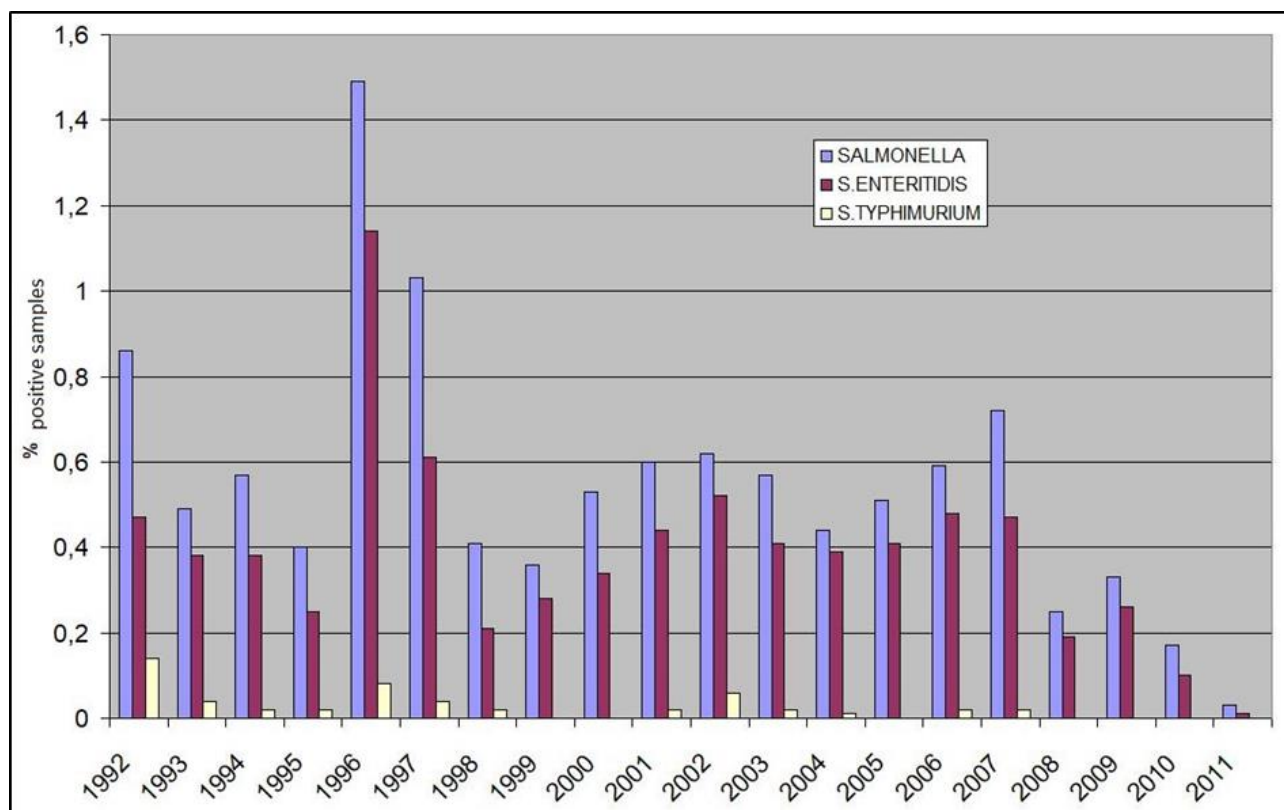


Figure 2. Table eggs 1992-2011 (from 1997 Plan samples).

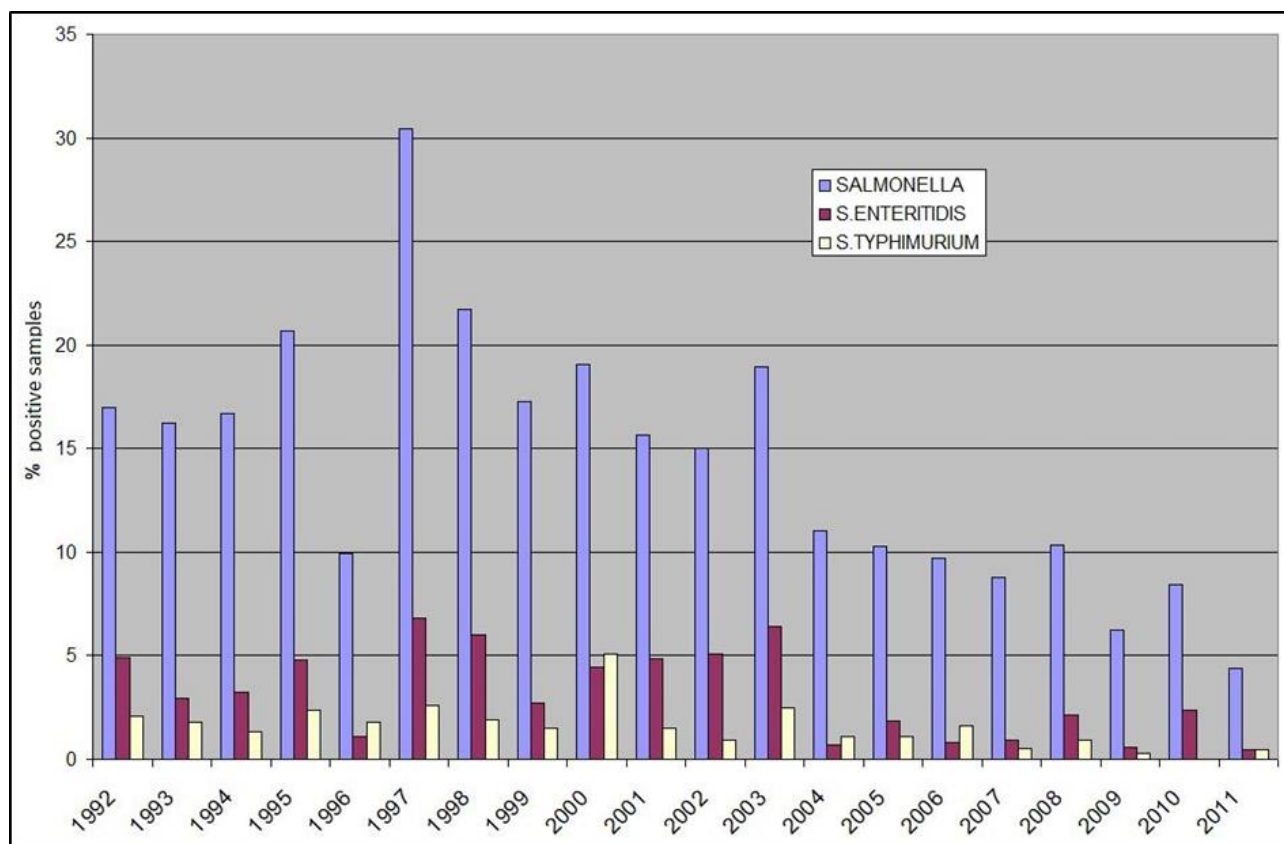


Figure 3. Broiler- and Hens meat 1992-2011 (from 1997 Plan samples).

The results of the analyses from several years (1992-2011) were used in this contribution using the examples of table eggs and poultry meat, which were responsible to human infections.

A correlation method was used since 2010.

2. Material and Methods

The in this contribution discussed data were originated from the years 1992 to 2011 and were analysed by different methods. The data on salmonella from 1992 to 1994 were collected under the Federal Health Institute. The data on zoonoses were compiled from 1995. For a better comparison the structure of the data from 1991 to 1994 was changed to the later zoonosis structure. From 1997 to 2003 the categories for meat of poultry and hens were introduced in contrast to the former years, where only poultry meat was reported, later more changes were performed, also according to recommendations from the federal regions. From 1996 all data on Zoonoses were formulated according to the zoonoses guide-

line 2003/99/EU.

The sending of zoonoses data included from 1997 the separated 'plan' samples from the food protection. 'Plan' samples are these samples, which are taken in regular times and in different locations according a plan (AVV RÜb, 2008, [2]). The compiled data were issued yearly in different journals ([6-27]).

Several analysis systems were included in the software of the zoonoses data set. Parallely a standard analysis and some other types including regional analysis could be used over several years. The analyses show the compiled investigation numbers and the percentages. Transferred data could be red into MS Excel and could be transferred as tables into MS Word. The images could be performed in MS Excel (Figures 1-3, 5) and in ESRI ArcGis (Figures 4, 6). The columns show the development during time and region. The data are also shown in Tables 1 and 2.

A correlation method was used since 2010 by a formula from Ms Excel.

Table 1. Region and detection level of Salmonella (from 1997 and Plan samples) in table eggs 1992-2011.

	1992 N	% pos.	1993 N	% pos.	1994 N	% pos.	1995 N	% pos.	1996 N	% pos.
SH	804	1.24	1090	0.18	151	0	367	0.54	57	3.51
HB	236	0.85	435	0	67	0	104	0.96		
HH	126	0	1051	0			1053	0.19	1048	0
NI	3638	1.32	10404	0.35	4407	0.79	7056	2	1361	0.59
ST	1556	4.31	4033	0.22	3733	0.59	7390	0.65	1129	4.52
MV	991	0.30	2640	0.15	2104	0.62	3834	0.89	1648	1.83
NW	8001	0.81	769	2.21	7532	0.41	9424	0.21	1000	1.6
BB	1080	2.04	3298	0.30	2696	0.78	3470	0.72	411	1.95
BE	800	0.63	3065	1.47	4451	0.47	2361	0	86	0
SL	510	0	1261	0.32	208	1.44	84	0	44	0
RP	877	0.46	1471	0.34	1402	0.14	768	0	150	0
HE	4390	3.21	913	0.55	435	0.23	288	3.13		
TH	2018	0.10	4760	0.23	1466	1.84	436	2.52	2444	0.61
SN	2922	0.55	5771	0.92	3050	0.23	4700	0.62	442	2.49
BW	3164	0.19	8446	0.53	7809	0.35	6970	0.13	1253	0.24
BY	22415	0.32	4427	0.36	3803	0.92	1321	0.61	322	8.07
DE		0.86		0.49		0.57		0.68		1.49

	1997 N	% pos.	1998 N	% pos.	1999 N	% pos.	2000 N	% pos.	N	% pos.
SH	2792	0.21	33	0	14	5.00	425	0.24	160	0
HB	60	10.00	25	4.00			13	0	20	5.00
HH	1708	0	717	0.28	356	0.77	128	0	480	0
NI	5586	1.83			1902	0.63	368	1.09	469	0.85
ST	14626	0.38	11850	0.23	6914	0.63	6950	0.22	4848	0.21
MV	2274	1.23	955	0.21	912	0.42	994	0.70	1167	0.51
NW	948	2.53	81		1424	0.12	327	1.22	313	1.28
BB	1050	1.14	1028	0.10	999	0.10	719	0.70	970	0.41
BE	77	3.90	123	2.44	162	1.23	441	0	30	0
SL	64	0	8	0	20	1.75	34	8.82	6	0
RP	312	1.28	177	0	1622	0	412	0.24	252	0.40
HE	82	0	173	0	10	0	46	0		
TH	1814	1.82	785	1.27	631	0	964	1.14	547	0.55
SN	1620	6.17	869	1.15	687	0.16	394	1.27	324	5.86
BW	562	7.47	224	0.89	579	0.35	206	5.83	861	1.51
BY	572	2.80	550	2.55	273	0.37	986	0.30	988	0.40
DE		1.03		0.41		0.36		0.53		0.6

	2002		2003		2004		2005		2006	
SH	213	0.47	39	0	52	1.92	18	0	16	6.25
HB	27	3.70	18	0			2	0	30	0
HH	91	1.10	47	0	18	0	9	0	2	0
NI	294	2.38	1335	0	355	0	137	0.73	39	2.56
ST	6456	0.29	5401	0.19	5809	0.12	2886	0.10	341	1.17
MV	1330	1.35	1220	0.49	630	0.32	1573	0.13	646	0
NW	577	0.52	446	2.91	233	0.86	476	0.42	1437	0.49
BB	358	0.84	430	1.40	334	0	273	1.10	242	2.07
BE	109	0.92	175	0.57	152	0	673	0.15	105	1.90
SL	54	0	67	0	5	0	12	0	553	0.18
RP	200	1.00	135	1.48	197	1.02	278	0	174	0.57
HE	647	0.77	59	0	123	0	756	1.32	169	0
TH	672	0.60	235	0.85	369	1.63	739	1.62	272	1.10
SN	368	2.72	357	3.36	296	1.35	265	1.51	237	0.84

	2002		2003		2004		2005		2006	
BW	658	1.82	610	0.66	719	2.92	89	3.37	411	0.24
BY	2381	0.13	424	1.65	887	0	99	1.01	87	0
DE		0.62		0.57		0.44		0.51		0.59
	2007		2008		2009		2010		2011	
SH	13	0	62	0	49	0	1080	0	402	0
HB					20	0			56	1.79
HH	100	0	38	0	176	0	46	0	9	0
NI	24	0	40	0	22	0	181	1.66	62	0
ST	402	1.00	3	0	225	1.33	342	0	250	0
MV	945	0.42	15	0	621	0.48	1178	0.17	623	0
NW	1585	0.88	1338	0.15	2233	0.22	729	0.14	1692	0.06
BB	233	0.43	3	0	208	1.92	547	0.18	172	0
BE	906	0	397	0	1	0	4	0	5	0
SL	41	0	1	0	49	0	23	0	64	0
RP	188	0.53	264	1.52	266	0	242	0	260	0.38
HE	1063	1.13	566	0	121	0	133	0.75	344	0
TH	296	1.01	5	0	87	0	112	0	127	0
SN	300	2.00	5	0	492	0.20	353	0	335	0
BW	272	0.37	1015	0	248	0.40	2264	0.04	11703	0.01
BY	14	0			666	0.15	2378	0.29	44	2.27
DE		0.72		0.25		0.33		0.17		0.03

Table 2. Regions of Salmonella-detections (from 1997 and Plan samples) in poultry meat 1992-2011^{1,2}.

	1992 ¹ N	% pos.	1993 ¹ N	% pos.	1994 ¹ N	% pos.	1995 ¹ N	% pos.	1996 ¹ N	% pos.	1997 N	% pos.
SH	247	2.43	74	20.27	247	23.08	50	22	39	23.08		
HB	47	25.53	77	22.08	454	9.91			26	15.38	8	0
HH	150	0	95	5.26	118	3.39	108	2.78	85	10.59	28	14.29
NI	335	11.34	293	12.97	376	21.01	108	18.52	1554	28.89	19	21.05
ST	738	4.34	354	19.21	289	9.69	40	62.5	72	12.50	58	27.59
MV	502	6.77	1346	8.17	1076	7.43	250	38	185	30.27	130	23.08
NW	133	19.55	198	24.24	169	18.93	129	19.38	132	12.88	106	13.21
BB	487	13.96	1351	6.00	296	22.64	97	37.11	261	11.49		
BE	323	15.48	285	31.58	110	16.36	86	41.86	61	29.51		

	1992 ¹ N	% pos.	1993 ¹ N	% pos.	1994 ¹ N	% pos.	1995 ¹ N	% pos.	1996 ¹ N	% pos.	1997 N	% pos.
SL	57	15.79	63	38.10	115	39.13	23	17.39	8	37.50	16	25.00
RP	157	5.10	108	18.52	98	4.08	99	12.12	62	30.65	38	15.79
HE	245	30.61	338	13.02	316	18.04						
TH	565	15.75	606	17.66	606	15.68	761	22.6	288	48.26	702	32.62
SN	824	11.53	576	17.19	526	13.50	509	19.84	237	26.16	124	64.52
BW	506	12.45	655	15.73	802	20.95	592	11.99	625	22.56	110	23.64
BY	941	48.78	641	43.37	988	25.10	408	28.92	344	33.72	384	35.94
DE		17.00		16.25		16.67		22.36		27.17		30.44

	1998 ² N	% pos.	1999 ² N	% pos.	2000 ² N	% pos.	2001 ² N	% pos.
SH	20	15.00	1	0	64	7.81	3	0
HB					14	0	11	0
HH	55	9.09	45	4.44	88	4.55	19	5.26
NI			127	14.96	102	1.96	137	25.55
ST	47	4.26	35	5.71	38	2.63	49	2.04
MV	79	24.05	74	12.16	70	14.29	118	23.73
NW	6	16.67	41	12.20	173	20.81	72	11.11
BB	51	21.57	45	13.33	12	16.67	82	10.98
BE	142	20.42	60	11.67	117	12.82	144	15.97
SL	14	0	22	4.55	14	7.14	1	0
RP	9	0	152	21.71	52	11.54	39	5.13
HE	58	8.62	38	7.89	44	4.55		
TH	240	32.92	187	24.06	206	25.24	203	11.33
SN			83	30.12	69	21.74	71	26.76
BW	168	15.48	184	20.11	115	27.83	45	11.11
BY	127	29.13	92	11.96	255	35.29	122	13.93
DE		21.70		17.28		19.07		15.68

	2002 ²		2003 ²		2004		2005		2006	
SH	94	9.57	19	10.53	100	9	12	41.67	5	20.00
HB	5	0	15	13.33	15	0				
HH	22	0	17	0	13	23.08	28	7.14		
NI	134	19.40	122	13.93	94	13.83	273	10.62	122	12.30
ST	82	10.98	44	13.64	52	3.85	138	8.70	104	2.88
MV	69	13.04	55	20.00	40	7.50	57	7.02	41	12.20
NW	156	13.46	73	6.85	25	16.00	104	4.81	110	11.82
BB			2	50.00	2	0				

	2002 ²		2003 ²		2004		2005		2006	
BE	61	1.64	89	16.85	98	9.18	63	6.35	118	8.47
SL	20	0	11	27.27	48	20.83	37	24.32	24	12.50
RP	83	10.84	32	12.50	105	5.71	21	9.52	5	20.00
HE	44	13.64	84	21.43	168	15.48	101	7.92	75	13.33
TH	220	14.55	199	13.07	48	4.17	118	5.93	131	8.40
SN	131	15.27	85	14.12			2	50.00	77	12.99
BW	76	18.42	152	21.71	197	11.17	62	3.23	182	8.79
BY	220	27.27	236	33.47	118	12.71	375	14.13	408	9.31
DE		15.01		16.46		11.04		10.28		9.70

	2007		2008		2009		2010		2011	
SH	4	25.00	6	0	7	0	9	0	12	0
HB	56	7.14			10	0			4	0
HH	42	0	92	1.09	7	14.29	34	5.88	32	6.25
NI	19	10.53	182	19.23	117	5.98	233	13.30	2	0
ST	32	6.25	1	0	37	5.41	71	7.04	9	22.22
MV	54	11.11			44	6.82	37	8.11	63	4.76
NW	108	10.19	93	6.45	201	6.47	220	4.55	462	1.95
BB	11	27.27	1	0	2	0	3	0	9	22.22
BE	81	6.17	102	2.94	90	3.33	80	5.00	79	7.59
SL	10	0			5	0	5	0	18	5.56
RP	76	10.53	79	5.06	22	13.64	18	5.56	1	0
HE	12	8.33	25	60.00	1	0	3	0		
TH	136	6.62	1	0	8	0	11	9.09	18	5.56
SN					6	33.33	2	0	8	12.50
BW	119	12.61	58	12.07	101	7.92	9	0	14	0
BY	2	0			10	0	105	13.33	86	10.47
DE		8.79		10.32		6.23		8.45		4.41

1) poultry meat. total - 2) Meat from poultry and hens meat - all other: poultry meat, TH (Thuringia). SN (Saxony). RP (Rhineland Palatinate). ST (Saxony-Anhalt). HS (Hesse). MV (Mecklenburg Western Pomerania). NW (Northrhine-Westphalia). NS (Lower Saxony). BY (Bavaria)

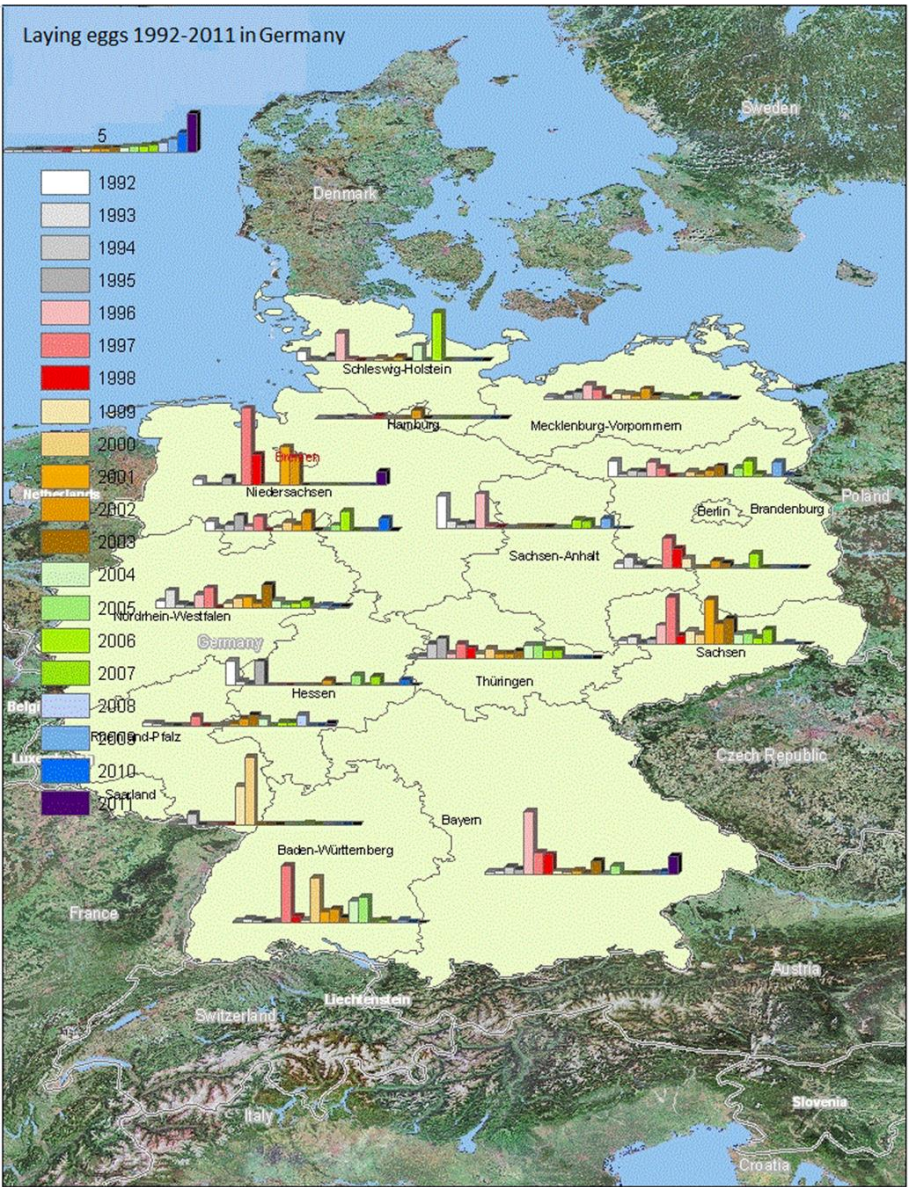


Figure 4. Table eggs 1992-2011- Thüringen (Thuringia). Sachsen (Saxony). Rheinland Pfalz (Rhineland Palatinate). Sachsen Anhalt (Saxony-Anhalt). Hessen (Hesse). Mecklenburg Vorpommern (Mecklenburg Western Pomerania). Nordrhein -Westfalen (Northrhine-Westphalia). Niedersachsen (Lower Saxony). Bayern (Bavaria).

Table 3. Time list of Surveillance with orders and regulars. and also the federal institutions.

Institution	Surveillance system	Year	Zoonoses regulation
Federal Health Institute (BGA)	Salmonella surveillance with questionnaires (MS Word. Manual database input)	1990	Federal epidemic law for human diseases
		1991	Start Salmonella surveillance
		1992	Zoonoses guideline (92/117/EWG)
		1994	Table egg order. hens-Salmonella order
		1995	New institute
Federal Institute for consumer protection and veterinary	Zoonosenes reporting	1996	National reference laboratory for the Epidemiology of Zoonoses (NRLE)
		1997	Food as plan samples reported

Institution	Surveillance system	Year	Zoonoses regulation
medicine (BgVV)	with Questionnaires (Excel)	2001	New infection protection law (IFSG)
		2004	Zoonoses guideline (2003/99/EG). Zoonoses-Protection order (VO EG No. 2160/2003)
	Questionnaires via e-mails und are au- tomatically red into a database	2005	Reporting Officer for the EFSA-Data transfer to EEC
		2006	Breeding hens VO EG Nr. 1003/2005
		2007	Laying hens VO EG Nr. 1168/2006
			Broiler VO EG No. 646/2007
		2008	Table eggs VO EG No. 1237/2007
		2009	Breeding turkey. VO EG No. 584/2008
		2011	Correlation over several years
Federal Institute for Risk Assess- ment (BfR)			

3. Results

In the Tables 1 and 2 the results according to the federal regions in Germany are shown, the data from 1997 shows 'Plan' samples.

In Figure 1 the infections in humans from 1991 to 2012 are shown. In this figure we can show the high infections level in 1992. From 1993 the levels of infection was continuously reduced. *S. enteritidis* was dropped down to 2008.

In Figure 2 the development of *S. enteritidis* and *S. typhimurium* in table eggs was shown from 1992 to 2011. After 1992 to about 2007 the contaminations of table eggs were of a different levels. These contaminations could be clearly reduced at a second time from 2008 on. In Figure 3 the results for poultry meat is shown. Poultry meat shows not

regular contaminations with salmonella. Also, in poultry meat the infections could be reduced from 1998 (cf. Table 1).

In Figure 3 the regional development of salmonella contaminations in table eggs since 1992 are shown. The highest detection levels were in the early years from 1992 to 2000. 1997 the absolute highest level was detected. Some regions have had higher levels of contaminations. Since 2008 the most regions have shown lower levels of salmonella contamination (cf. Table 2).

In Figure 4 the regional development of salmonella contaminations in poultry meat is shown. In some regions some higher levels could be seen. Many regions show from the 1990 years higher contamination levels up to 2005. From 2005 a reduction of the levels could be shown.

In Figure 5 is shown the correlation of table eggs and poultry meat with human prevalences.

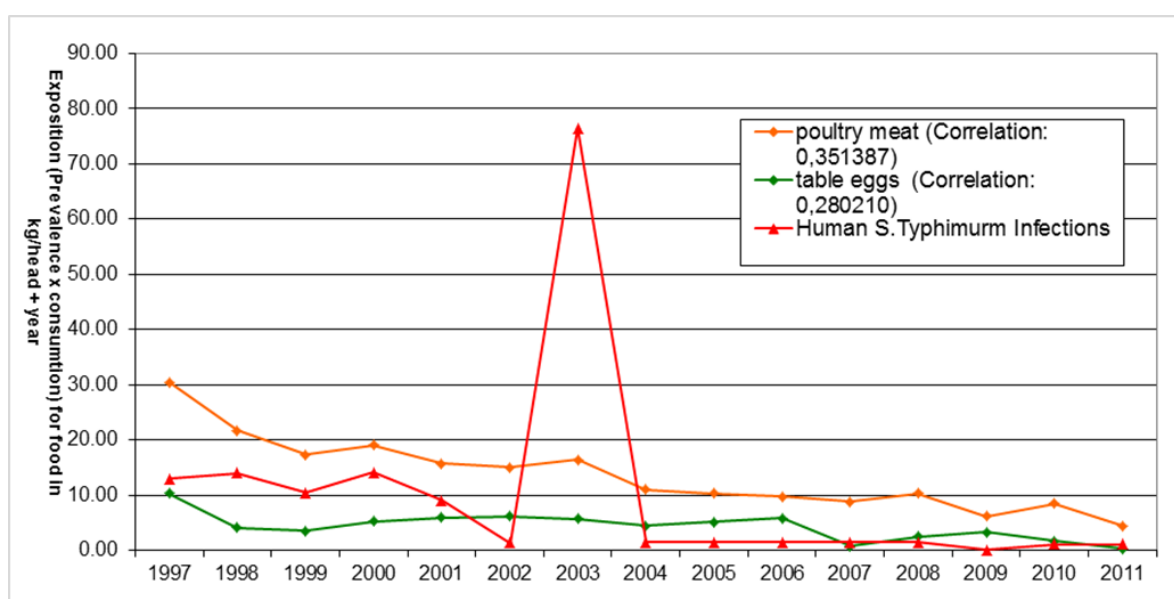


Figure 5. Correlation of table eggs and poultry meat with human incidences.

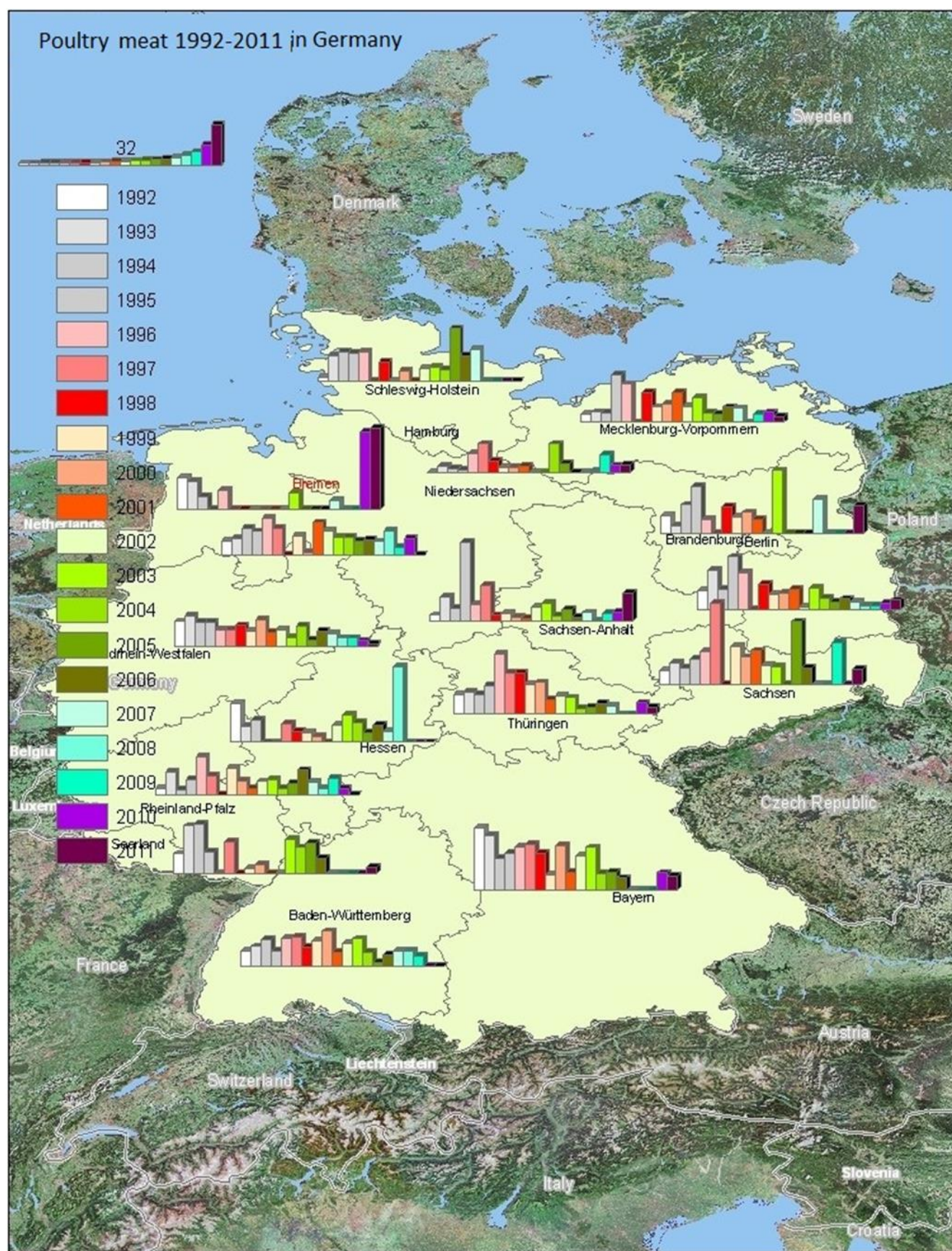


Figure 6. Meat from poultry meat 1992-2011 - Thüringen (Thuringia). Sachsen (Saxony). Rheinland Pfalz (Rhineland Palatinate). Sachsen Anhalt (Saxony-Anhalt). Hessen (Hesse). Mecklenburg Vorpommern (Mecklenburg Western Pomerania). Nordrhein-Westfalen (Northrhine-Westphalia). Niedersachsen (Lower Saxony). Bayern (Bavaria).

4. Discussion

From 1992 to 2011 the collected categories were regular enhanced, also according to recommendations from the regions. The main detection samples come from so called 'Plan' samples from 1997, regarding mostly food samples. Therefore the other categories have no meaning. So, all the data are comparable. Due to the years some regions have not sent data. Since 1996 the sending of data by the regions were enhanced each year.

The contamination level of poultry meat was always high (Table 2). In Figure 2 a remarkable reduction of the contaminations with salmonella was observed between 2003 and 2011. Since 2008 the order (EU No. 646/2007) was introduced to reduce salmonella in poultry herds.

One other aspect gives the development of the table eggs (Figure 2) from 2007 to 2008. From 2008 the reduction of the salmonella contaminations was shown to a low level, from 2007 on the quality of data collection was clearly enhanced. *S. enteritidis* shows from 1992 a high level of contamination. The contamination level of *S. typhimurium* was reduced. From 1994 on the number of human infections were reduced. After introduction of the order (EU No. 1168/2006, [32]) for the reduction of salmonellosis in poultry herds, the contamination of table eggs were reduced to nearly zero level from 2008. In the same time the number of human infections were reduced (Figure 1). The prevalence of table eggs have in the years 1997 to 2011 a correlation value of 0.28 and with poultry meat a correlation value of 0.35; (Figure 5) [28].

In Table 1 and Figure 4 the regional distribution of the contaminations from table eggs in the regions in Germany is shown (cf. tab. 1). The three regions with the highest contaminations were detected in Saxonian, Baden-Württemberg and Bavaria.

A regional compilation (Table 2, Figure 6) was also shown for poultry meat. The region with the highest contamination level were Bavaria, Thuringia and Saxonian.

The regions with most high contaminations are in the East and South of Germany, mainly from 1992 to 1997. A possible cause for the contamination may be an import from contaminated feed.

In Germany the incidence in humans was in 1991 with 53 cases from 100 000 inhabitants, 1992 with 243 cases. In both years the part of *S. enteritidis* was 90% [30]. Also, from several neighbour countries high incidences of salmonella are reported 1990-1992. In Chechia the part of *S. enteritidis* in humans reached 84% and an incidence of 350. In Hungaria the detection level of *S. enteritidis* reached 80% of the salmonellosis with an incidence of 108. Also, in Austria an incidence of *S. enteritidis* at 116 (1991) and 142 (1992). The main infections in humans with *S. enteritidis* in the neighbour countries could be compared with Germany.

The analysis could show, that a compilation of data is possible over 20 years. The analysis should be interpreted care-

fully. According to the analysis (1992-2011) the *S. enteritidis*-infections come possibly from South East of Europe. From 2008 the success of reduction the salmonella infections is shown (EU No. 1168/2006). Further analysis can show that the reduction of salmonella infection in the neighbour countries was parallelly to Germany.

Since 1994 the number of human salmonellosis were reduced in Germany. The order for hens salmonellosis (1994) has had a big influence on the infection level in Hens, also due to the vaccination. Parallelly the order on table eggs (1994) was introduced. The reduction of human salmonellosis was clearly shown from 1993.

Since 2007/2008 the number of human salmonellosis in Germany was reduced again up to 2012, also the infections with *S. enteritidis* were reduced (Figure 1). *S. enteritidis* was reduced in nearly all foods and animals. A big influence came from the order EU No. 1168/2006 and No. 1237/2007.

Author Contributions

Matthias Hartung is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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